Managing the Nation's Commercial High-Level Radioactive Waste

Summary

CONGRESS OF THE UNITED STATES
Office of Technology Assessment
Washington, D.C. 20510

J952-15

Office of Technology Assessment

Congressional Board of the 99th Congress

TED STEVENS, *Alaska, Chairman*

MORRIS K. UDALL, *Arizona, Vice Chairman*

Senate

ORRIN G. HATCH
Utah

CHARLES McC. MATHIAS, JR.
Maryland

EDWARD M. KENNEDY
Massachusetts

ERNEST F. HOLLINGS
South Carolina

CLAIBORNE PELL
Rhode Island

House

GEORGE E. BROWN, JR.
California

JOHN D. DINGELL
Michigan

CLARENCE E. MILLER
Ohio

COOPER EVANS
Iowa

Vacant

JOHN H. GIBBONS
(Nonvoting)

Advisory Council

WILLIAM J. PERRY, *Chairman*
Hambrecht & Quist

DAVID S. POTTER, *Vice Chairman*
General Motors Corp.

EARL BEISTLINE
University of Alaska

CHARLES A. BOWSHER
General Accounting Office

CLAIRE T. DEDRICK
California Land Commission

JAMES C. FLETCHER
University of Pittsburgh

S. DAVID FREEMAN
Consultant

GILBERT GUDE
Congressional Research Service

CARL N. HODGES
University of Arizona

CHARLES N. KIMBALL
Midwest Research Institute

RACHEL McCULLOUCH
University of Wisconsin

LEWIS THOMAS
Memorial Sloan-Kettering Cancer Center

Director

JOHN H. GIBBONS

The Technology Assessment Board approves the release of this report. The views expressed in this report are not necessarily those of the Board, OTA Advisory Council, or of individual members thereof.

Foreword

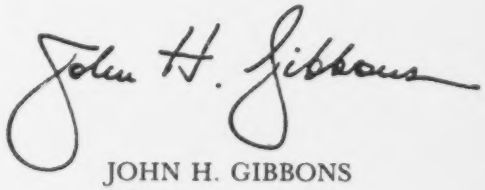
This summary presents the findings and conclusions of OTA's analysis of Federal policy for the management of commercial high-level radioactive waste. It represents a major update and expansion of the analysis presented to Congress in our summary report, *Managing Commercial High-Level Radioactive Waste,* published in April of 1982 during the debate leading to passage of the Nuclear Waste Policy Act of 1982 (NWPA). This summary and the full report are intended to contribute to the implementation of NWPA, and in particular to congressional review of three major documents that the Department of Energy (DOE) will submit to the 99th Congress:

- a Mission Plan for the waste management program;
- a monitored retrievable storage (MRS) proposal; and
- a report on mechanisms for financing and managing the waste program.

The assessment was originally undertaken at the request of the House Committee on Merchant Marine and Fisheries and focused on the ocean disposal of nuclear waste. OTA later broadened the study to include all aspects of high-level waste disposal after expressions of interest and support by the Senate Committees on Energy and Natural Resources and on Commerce, Science, and Technology; by the Senate National Ocean Policy Study; and by the House Committees on Science and Technology and on Foreign Affairs. Additional requests for related analysis were later received from the Senate Committee on Environment and Public Works and from the House Committees on Interior and Insular Affairs and on Energy and Commerce. The major findings of the original analysis were published in OTA's 1982 summary report.

Following passage of NWPA, the House Committee on Rules asked OTA to analyze the Act from the perspective of the policy conclusions of our 1982 study. In addition, the House Committees on Interior and Insular Affairs and on Energy and Commerce asked OTA to provide information on the Mission Plan required by NWPA. This summary presents the major findings of these additional analyses and the key options regarding the Mission Plan and other documents mentioned above.

OTA is grateful for the assistance of the advisory panel for this assessment, as well as the support and guidance received from many other people and organizations, including the Department of Energy, the Nuclear Regulatory Commission, and the Environmental Protection Agency. OTA assumes full responsibility for the summary and full report.



JOHN H. GIBBONS
Director

Advisory Panel on Commercial High-Level Radioactive Waste

Hans Frauenfelder, *Chairman*
Department of Physics, University of Illinois

Seymour Abrahamson
Department of Zoology
University of Wisconsin

Frank Collins
Consultant

Floyd Culler
President
Electric Power Research Institute

J. William Futrell
President
Environmental Law Institute

Edward Goldberg
Scripps Institution of Oceanography
University of California

William W. Hambleton
Director
Kansas Geological Survey

Hon. Harriet Keyserling
House of Representatives
State of South Carolina

Terry Lash
Director
Illinois Department of Nuclear Safety

Kai Lee
Institute for Environmental Studies
University of Washington

Hon. Jeanne Malchon
Senate
State of Florida

Peter Montague
Center for Environmental Studies
Princeton University

Glenn Paulson
Vice President for Science
National Audubon Society

Howard Raiffa
Harvard Business School

William A. Thomas
Research Attorney
American Bar Foundation

Mason Willrich
Vice President—Corporate Planning
Pacific Gas & Electric Co.

Donald Wodrich
Rockwell International-Hanford Operations

John Yasinsky
Advanced Power Systems Division
Westinghouse Electric Corp.

NOTE: The Advisory Panel provided advice and comment throughout the assessment, but the members do not necessarily approve, disapprove, or endorse the report, for which OTA assumes full responsibility.

OTA Commercial High-Level Radioactive Waste Project Staff

John Andelin, *Assistant Director, OTA*
Science, Information, and Natural Resources Division

Robert Niblock, *Oceans and Environment Program Manager*
Thomas Cotton, *Project Director*
William Barnard, *Assistant Project Director*
John Burns, *Editor and Writer*
Daniel Kevin, *Analyst*
Kathryn Van Wyk,** *Editor and Writer*

Administrative Staff

Kathleen Beil
Jacquelynne Mulder

Contributing Staff

Prudence Adler, Junior Bridge, Anne Fenn, Linda Garcia, Emilia Govan, Barry Holt, Peter Johnson, Robert Leachman*, James Payne, Paul B. Phelps, Richard Raymond**, Ralph Smalley, Lucia Turnbull

Contractors

Academy for Contemporary Problems
American Planning Association
Applied Decision Analysis
Battelle Memorial Institute
Human Affairs Research Centers
David Carr
William Colglazier
David Deese
Forecast Systems, Inc.
William Giese
Harvard University
Barbara Katz
Todd LaPorte
Daniel Metlay
Gene Rochlin
Sanford Strenger**
Teknekron Research, Inc.
The George Washington University
The MITRE Corp.
Toner & Associates, Inc.
Patrick Windham
David Zellner

Public Participation Working Group

Susan Bistline, Alfred Carter, Jr., Mildred Clark, Barbara Jackson, Janet Kramer, William Pounds, Barbara Ruff, Gregory Smith, James Stewart

*NRC detailee.
**In-house contractor.

Managing the Nation's Commercial High-Level Radioactive Waste

OVERVIEW

With the passage of the Nuclear Waste Policy Act of 1982 (NWPA), Congress for the first time established in law a comprehensive Federal policy for commercial high-level radioactive waste management, including interim storage and permanent disposal. **NWPA provides sufficient authority for developing and operating a high-level radioactive waste management system based on disposal in mined geologic repositories.** Authorization for other types of waste facilities will not be required unless major problems with geologic disposal are discovered, and studies to date have identified no insurmountable technical obstacles to developing geologic repositories.

The 99th Congress will receive three key documents that NWPA requires the Department of Energy (DOE) to prepare:

1. *a Mission Plan,* containing both a *waste management plan* with a schedule for transferring waste to Federal facilities and an *implementation program* for choosing sites and developing technologies to carry out that plan;
2. *a monitored retrievable storage (MRS) proposal,* with designs for long-term Federal storage facilities, evaluations of whether they are needed and feasible, and analysis of how they would be integrated with the repository program if authorized by Congress; and
3. *a study of alternative institutional mechanisms* for financing and managing the radioactive waste system, including the option of establishing an independent waste management organization outside of DOE.

Each of these documents will raise issues of potentially significant concern to Congress and the Nation.

The Mission Plan

The crucial next step for stabilizing the U.S. radioactive waste management program, and for building confidence that nuclear waste can and ultimately will be disposed of safely, is to develop a credible Mission Plan that is widely viewed as achievable and responsive to the concerns of the major affected parties. According to NWPA, the document to be submitted by DOE is intended to provide "an informational basis sufficient to permit informed decisions to be made." To do this, it must identify the key decisions in developing the waste management system, analyze and compare the technical and programmatic options, and thereby provide the information

that would support DOE's choice among the options. In OTA's view, the *Draft Mission Plan* published by DOE in April 1984 does not meet this test. OTA believes that the preparation of a final Mission Plan offers DOE a major opportunity to enhance the credibility and acceptability of the waste management program.

As part of its analysis of NWPA, OTA has identified the elements of a Mission Plan that can meet the requirements of the Act using only the authority it provides. Comparison between this "OTA Mission Plan" and DOE's *Draft Mission Plan* provides a basis for identifying the major strategic decisions in the Mission Plan. Comparison also reveals several areas in which additional analysis by DOE would provide valuable information for congressional deliberations during the 30 working days that the Mission Plan lies before Congress before becoming effective. In general, the OTA Mission Plan represents an expansion, rather than a redirection, of the approach in DOE's *Draft Mission Plan.* None of DOE's ongoing repository siting or development activities need or should be deferred pending development of a final Mission Plan.

The major difference between the two Mission Plans lies in the measures used to provide confidence that spent fuel will be removed from reactor sites within a reasonable period, despite the technical and institutional uncertainties associated with siting and licensing the first geologic repository. DOE's *Draft Mission Plan* is based on a repository loading schedule that allows for no problems or delays in choosing or licensing the first repository. The repository siting program includes no backups for the sites that NWPA requires to be evaluated at key stages of the siting process. To provide confidence that waste can be accepted in the event that this siting program encounters significant delays, the *Draft Mission Plan* proposes to ask Congress for new legislative authority to site and license an MRS facility so that one could be constructed as early as 1998, if needed.

The OTA Mission Plan, on the other hand, relies on the existing authority in NWPA to the maximum extent possible. It recognizes that the first geologic repository required by NWPA is the only facility DOE is now authorized to site and use to accept high-level radioactive waste.[1] It uses a repository loading schedule that can be met despite technical or institutional difficulties, and an aggressive implementation program designed to reduce the risk of extended delays in the repository program. In particular, it adds one backup site to those required by NWPA at critical siting steps. The OTA Mission Plan would ask for new legislative authority to construct MRS facilities or alternative disposal facilities only as a last resort, if major problems call into question the feasibility of geologic disposal.

The repository program in the OTA Mission Plan differs from that in DOE's *Draft Mission Plan* in three key respects: the repository loading schedule, the repository siting strategy, and the strategy for developing the first repository. The issues in these areas are discussed in the remainder of this

[1]NWPA requires DOE to site and license a second repository, and limits the amount of waste that can be emplaced in the first before the second begins operating. NWPA does not explicitly authorize construction of the second repository.

section; issues concerning the role of the MRS are discussed in the following section, which deals with the separate MRS proposal required by NWPA.

Repository Loading Schedule

A schedule for loading the geologic repositories is needed as a basis for contractual commitments by DOE to accept waste from utilities. The crucial decision concerning the repository loading schedule is the balance between the degree of certainty that the schedule can be met, and the promised speed of the schedule. The more optimistic the schedule for contractual commitments, the more likely it will be that they cannot be met using the first geologic repository, and that other means will be needed to meet Federal obligations. DOE's *Draft Mission Plan* uses an optimistic repository schedule that can be met only if no significant delays are encountered. If all goes well, loading at the repository (using limited packaging facilities) would begin by 1998, the year in which NWPA requires initial disposal in the first repository. Operation of full-scale facilities would begin by about 2001. DOE does not specify when loading might begin if there are problems or delays.

The OTA Mission Plan also uses the 1998 target as a management goal for initial disposal of a small amount of waste packaged during the technology development program. However, it bases contractual commitments with utilities on a conservative schedule for full-scale repository operation. This loading schedule can be met despite the delays that can be expected in the effort to site the first repository. Specifically, **OTA concludes that use of an aggressive implementation program (discussed below) can give considerable confidence that the two repositories required by NWPA can be operating full-scale by 2008 and 2012, respectively, even if significant delays are encountered.** If such delays do not materialize, full-scale loading could begin years earlier, and the actual schedule could match that proposed by DOE.

Repository Siting Program

The credibility of any repository loading schedule depends on the credibility of the implementation program supporting it. The major decision concerning the implementation program is the balance between the initial costs of the program and the certainty of getting the job done without major problems or delays. This is particularly important in the repository siting program.

DOE's *Draft Mission Plan* uses a reactive approach in its implementation program. In particular, the siting program considers only the number of sites required by NWPA: that is, for each repository, three sites would be investigated at depth ("characterized"), and one site would be recommended for licensing. Backups would be developed only *after* it is certain they are needed. This strategy is unchanged from the one in use before the NWPA made a commitment to a schedule for operation of a repository.

By contrast, the OTA Mission Plan uses a preventive approach involving development of backup sites before they might be needed, to minimize the delays that could result if there are difficulties with the primary candidate sites. In particular, it provides for characterization of four sites, and recommendation of two for licensing, for each repository.

Adding one backup to the number of sites NWPA requires at each stage significantly reduces the risk that the siting process will be delayed by problems at any one site. This approach may cost more at the start, but over the long run its financial and political costs may well be less than those of a program that makes no allowance for major delays or problems. Among those potential costs is the risk that programmatic failures could damage the credibility of the Federal program. Thus any extra initial costs can be seen as the price of insurance against these difficulties. Congress may therefore wish to ask DOE to analyze the additional cost of this approach, if any, and its effectiveness in raising the confidence of the proposed repository loading schedule.

Technology Development Plan

In DOE's *Draft Mission Plan,* the schedule for developing the final designs for the repository and waste package is driven by the optimistic repository loading schedule, which requires rapid construction of packaging facilities at the site after the Nuclear Regulatory Commission (NRC) construction authorization is granted. This approach makes initial disposal dependent on the construction schedule of the packaging facilities. The pressure to complete those facilities in time to meet the 1998 deadline may preclude use of one of the new integrated system designs now under development that have the potential for significantly reducing the costs and impacts of waste management.

To avoid this potential problem, the OTA Mission Plan suggests that the first repository be developed in two phases. A *small-scale demonstration phase* would begin as soon as allowed by NRC following its approval of a construction authorization. This would involve licensed emplacement of a small amount of waste packaged during the repository research, development, and demonstration (RD&D) program using a *conservative system design*, one that emphasizes certainty in meeting NRC's requirements for disposal, rather than overall efficiency of waste management operations.

The *full-scale operational phase* would begin after the development and licensing of an *integrated, optimized system design* that takes advantage of the most advanced available technology to reduce the risks, costs, and impacts of the entire waste management operation, from discharge of spent fuel from the reactor to final disposal in a repository. Planning for initial licensed disposal before the repository's own packaging facilities are constructed maximizes the likelihood that the 1998 deadline will be met, and allows the schedule for construction of those facilities to be determined by the time required for an aggressive RD&D program to develop the integrated system design.

The Monitored Retrievable Storage Proposal

It now appears that MRS facilities will not be necessary for safe waste management. NWPA requires that the utilities themselves provide interim spent fuel storage until a repository is available. This storage can probably be provided at reactor sites, even after the 1998 deadline. OTA's Mission Plan provides for MRS facilities to be available as a long-term backup to repositories, **but only in the event that major unanticipated difficulties are encountered with geologic disposal.**

The major storage issues to be addressed in both the Mission Plan and the MRS proposal are *when* and *whether* DOE should be authorized to construct a centralized MRS facility, and *what role* it would play in the integrated waste management system. OTA's analysis suggests that, to aid congressional deliberations, the MRS proposal submitted by DOE should evaluate at least three alternatives:

1. **Early siting, licensing, and construction of an MRS facility.** This option, which is implicit in DOE's *Draft Mission Plan,* would require congressional authorization in the near future. It would allow DOE to accept waste on a large scale beginning in 1998, even if there are delays in the repository program. It involves a commitment of additional manpower and resources over the next decade, above and beyond those already involved in the repository siting process.
2. **Federal at-reactor storage beginning in 1998.** This might be accomplished through rulemaking, by modifying contracts with utilities to provide that the Federal radioactive waste program would pay the costs of additional storage beyond the contractual delivery date, thus spreading the costs of delays in the repository program among all utilities paying the waste disposal fee. If so, no congressional action would be required.
3. **Deferral of the decision on a centralized MRS facility until at least 1990, when the first repository site is to be recommended to Congress.** This allows the decision to be made based on much more information about storage options, integrated waste management system designs, and the progress of the repository program than is currently available. It also avoids the risk that an early effort to site a large-scale storage facility would delay the repository program. This option would require no congressional action at this time.

Alternative Means of Financing and Management

NWPA also requires DOE to submit a study of alternative institutional mechanisms for financing and managing the radioactive waste system, including the options of an independent agency or even a private corporation. A public advisory committee established by DOE to address this subject recommended consideration of a federally chartered public corporation. **OTA's analysis suggests that the credibility of NWPA's commitment to the development of a first-of-a-kind technological system on a firm schedule could be significantly enhanced by the establishment of an independent waste management agency with more funding and management flexibility than is typical in a Federal program.** The more independent the institution and its funding, the surer the guarantee that a complex program will be carried out on schedule and will not be disrupted by other fiscal or political priorities of the Federal Government.

Balancing independence and accountability is a key challenge in designing an independent waste management agency. A congressionally approved Mission Plan could serve as the principal mechanism for balancing effective congressional control with increased flexibility of operation. In fact, it may not be possible to gain broad support for the creation of an independent institution with independent funding *until* a generally accepted Mission Plan—one that spells out exactly what the agency is to do—is developed. If

it were formally approved by Congress, the Mission Plan could serve as the main yardstick for overseeing the activities and expenditures of the waste management agency and for measuring its progress. Since approval of the Mission Plan is not now required by NWPA, consideration of mechanisms for such approval might be included in any congressional deliberations on establishing an independent waste management agency.

BACKGROUND

When the 97th Congress began considering comprehensive waste management legislation in 1981, there were 74 commercial nuclear powerplants in operation in the United States, and some 85 additional plants were under construction. Approximately 8,000 metric tons (tonnes) of commercial spent (used) nuclear fuel, containing highly radioactive waste products, had already been generated. Yet the United States still had not decided how to deal with the problem of isolating those waste products from the environment for the thousands of years required for the radioactivity of the waste to decay to low levels.

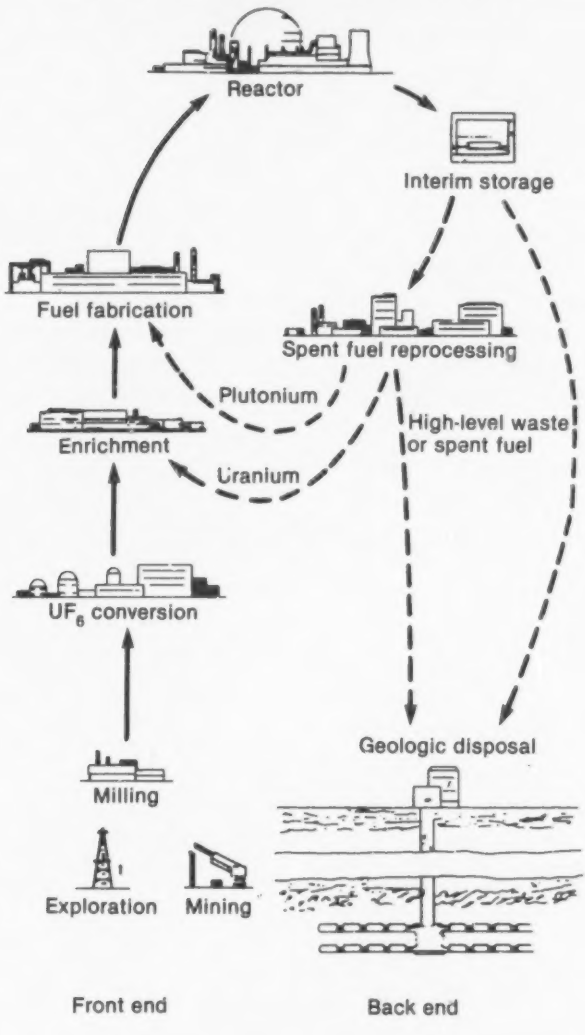
Nearly all of the spent fuel produced thus far by commercial nuclear powerplants is temporarily stored in water-filled basins at operating reactors. The original expectation—that all spent fuel would be reprocessed to recover usable uranium and plutonium, and that the radioactive byproducts would be separated as high-level waste—has not been realized. It now appears possible that much of the spent fuel will be discarded directly as waste (see fig. 1).

The lack of final isolation facilities raised two key problems for the nuclear industry. First, some critics questioned the continued use of nuclear power, arguing that the failure to develop final isolation facilities was evidence that waste isolation might be an insoluble problem. Second, the lack of reprocessing or disposal facilities to accept spent fuel left utilities that owned nuclear reactors with a growing spent fuel storage problem. In the near term, operating reactors were running out of storage space, and some faced the possibility of having to shut down unless additional storage capacity were made available in a timely manner. In the longer term, the absence of a firm schedule for either reprocessing or turning spent fuel over to the Federal Government left utilities uncertain about how much additional storage capacity they would have to provide, when they would end their liability for growing inventories of spent fuel, and how much storage and disposal would ultimately cost.

The storage problem was complicated by increasing opposition to the efforts of utilities and the Federal Government to provide additional storage capacity. This opposition resulted from concern that the easy availability of interim *storage* would reduce the pressure for developing a Federal *disposal* system, thereby turning interim storage facilities into de facto permanent waste repositories. This opposition, in turn, had increased utilities' fears that they might not be able to gain approval for additional storage facilities quickly enough to prevent reactor shutdowns.

The problems facing the nuclear industry, combined with the broader societal concern that nuclear waste be dealt with responsibly, generated considerable pressure to proceed promptly to develop final isolation facilities. The challenge facing Congress was to develop a *comprehensive* waste man-

Figure 1.—The Nuclear Fuel Cycle



The commercial nuclear fuel cycle includes activities for preparing and using reactor fuel and for managing spent fuel and other radioactive wastes produced in the process. It was originally intended that spent fuel be stored for 6 months in water-filled basins at reactor sites to dissipate thermal heat and allow decay of short-lived fission products. The spent fuel would then be reprocessed and the resultant liquid high-level waste solidified and disposed of in a Federal repository. Since no repository has been developed and no commercial reprocessing is being done, spent fuel will remain in storage until repositories are available to close the nuclear fuel cycle.

SOURCE: Council on Environmental Quality.

44-015 O - 85 - 2

agement policy: one that dealt with interim storage in the context of final isolation and provided the stability of purpose and direction that had been lacking in previous Federal waste management efforts.

Earlier problems in the Federal program complicated the development of such a policy. First, some doubted that the existing Federal institutional arrangements were capable of successfully implementing waste management policy over a period of decades. Second, the distrust that had developed between the Federal Government and those States affected by waste management activities seriously complicated efforts to reach agreement on a program for siting permanent repositories. On the one hand, potential host States and other groups feared that the Federal Government might cut corners, simply to be able to say that the problem had been solved. On the other hand, some in the Federal Government feared that at least some States might seek to block any waste management activities within their borders, no matter what assurances of safety were provided.

Congress addressed all of these problems in NWPA by including measures that specify:

1. a comprehensive Federal policy for high-level radioactive waste management that spells out the responsibilities of the utilities and the Federal Government;
2. relationships between the Federal Government and the States and Indian tribes affected by waste management activities; and
3. improvements in the institutional mechanisms through which the Federal Government will carry out that policy.

These measures are summarized briefly below, as background for discussion of the issues that remain to be resolved during implementation of the Act.

THE NUCLEAR WASTE POLICY ACT OF 1982

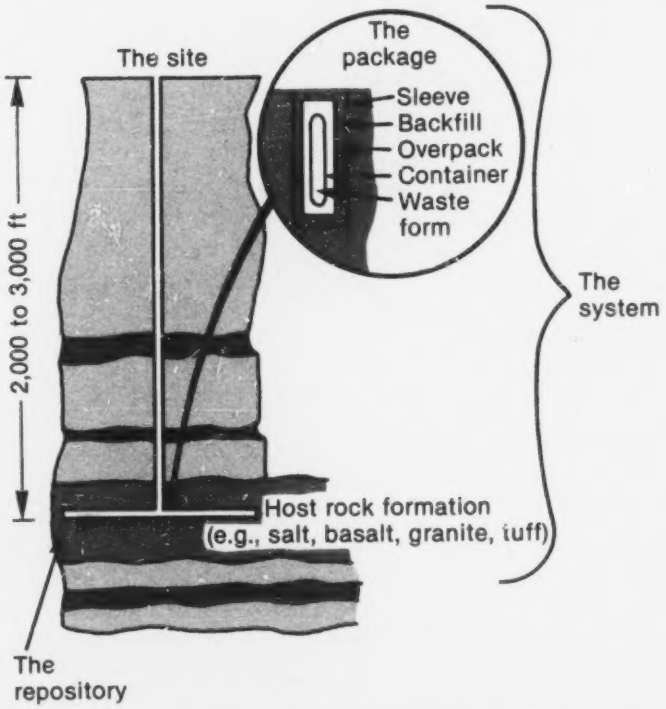
Waste Management Policy

Final Isolation of Nuclear Waste

NWPA establishes a schedule for DOE to site, and for NRC to decide on licenses for, two geologic repositories (see fig. 2) for permanent disposal of civilian high-level radioactive waste. This schedule requires that DOE *begin* disposing of waste at the first repository not later than January 31, 1998. The repositories are to be able to handle both commercial spent fuel and high-level waste from reprocessing. They are also to be used for high-level waste from defense nuclear activities unless the President determines that separate repositories for defense waste are needed. (A draft DOE study concludes that disposing of defense and commercial wastes in the same repositories would be the most cost-effective option.)

The two repositories required by the Act appear to be both necessary and sufficient to dispose of the waste from commercial reactors that are now operating or under construction, as well as currently projected amounts of defense high-level wastes. Nearly 30 years of study have revealed no insurmountable technical obstacles to the successful development

Figure 2.—Mined Geologic Disposal Concept



Mined geologic disposal will use a system comprised of engineered barriers (the waste package and the mined repository) and naturally occurring barriers (the host rock formation and the chemical and physical properties of the repository site itself) to provide long-term isolation of waste from the biosphere. Three decades of extensive study have revealed no insurmountable technical obstacles to the development of mined geologic repositories, provided suitable sites are found.

SOURCE: Department of Energy.

of mined geologic repositories, although suitable sites must still be found. **OTA believes that small-scale disposal could begin by the 1998 target for *initial* operation of the first repository,** if a suitable site can be selected from among those under investigation at the time NWPA was passed. (Measures to increase the likelihood of success are discussed below.) **OTA also concludes that an expanded siting and development program can give considerable confidence that the two repositories required by NWPA could be operating at full scale by no later than 2008 and 2012, respectively, even if there are major delays or if backup sites must be used.**[2]

[2]These dates are conservative in comparison with DOE's schedule for the second repository, which suggests that a repository using a site and a geologic medium not among those under consideration for the first repository could be available by 2005.

OTA's review of the history of the waste management program concludes that a commitment in law to a firm schedule for operation of a Federal disposal facility (as enacted in NWPA) would play a central role in a comprehensive, broadly supported waste management policy. This commitment is needed for three major reasons. First, the history of opposition to proposals for Federal *storage* facilities suggests that, to satisfy public concerns, it will be necessary to develop permanent *disposal* facilities (see box). Second, a firm and believable schedule for a repository decreases concern that spent fuel would remain in interim storage indefinitely, a major source of resistance to past efforts to provide additional interim storage. Finally, the key measures needed to give that commitment credibility (i.e., an aggressive implementation program involving backup repository sites and disposal technologies) would address a major concern about the Federal waste management program in the past—the concern that crucial decisions might be compromised by the lack of options.

Interim Storage of Spent Fuel

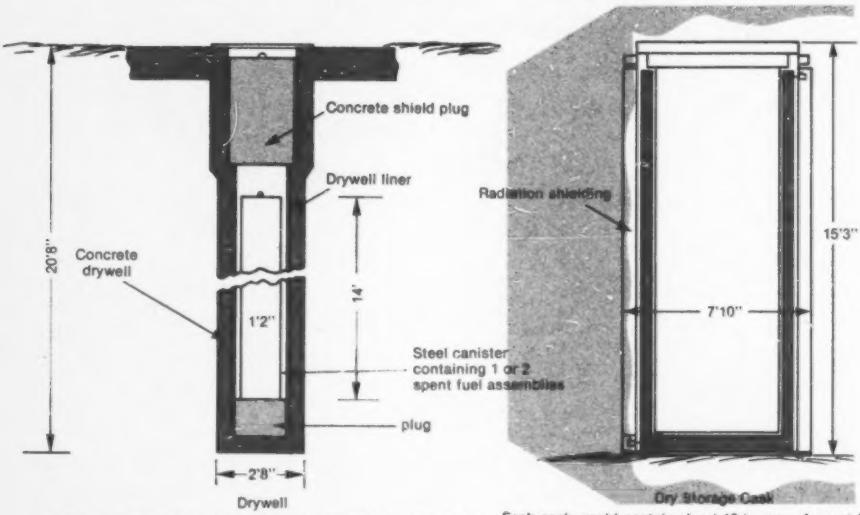
NWPA gives utilities that operate nuclear reactors the primary responsibility for storing spent fuel until it can be delivered to a permanent repository. The Act also contains measures to help utilities provide such storage at reactor sites using new dry storage technologies (see fig. 3). DOE now expects that these measures can preclude the need to use the 1,900 tonnes of "last resort" Federal storage capacity, which the Act makes available to utilities that are unable to provide their own storage in time to prevent disruption of reactor operations.

Storage and Disposal: A Basic Distinction

Much of the debate about radioactive waste has been clouded by blurred and shifting distinctions between **disposal** and **storage**, which are different technological approaches to the **isolation** of radioactive waste from the biosphere. Briefly, **disposal** is isolation that relies only on natural (environmental) and manmade barriers, does not permit easy human access to the waste after its final emplacement, and does not require continued human control and maintenance. **Storage** is isolation that permits easy access to the waste after its emplacement and requires human control and maintenance in order to guarantee isolation. Thus, disposal is always designed to provide final isolation (the last step in the waste management process), while storage may be intended for either final or interim (temporary) isolation. Because storage requires human control and maintenance, while disposal requires none, **disposal and storage are not synonymous terms.**

BEST AVAILABLE COPY

Figure 3.—Dry Storage Concepts for Spent Fuel



Each drywell would hold a steel canister containing about 0.5 tonnes of spent fuel (1 or 2 fuel assemblies depending upon the type of reactor).

Each cask would contain about 10 tonnes of spent fuel (24 to 52 assemblies).

If licensed, dry storage technologies like these may provide a relatively inexpensive, flexible alternative to water-filled basins for in-

There appear to be no fundamental technical questions about the ability to design, construct, and operate storage facilities for spent fuel or reprocessed waste to meet applicable radiation protection standards, as long as continuing surveillance and maintenance of the facilities is provided. Safe storage in water basins has already been demonstrated for periods of up to 20 years, and new dry storage technologies (storage casks, drywells, and concrete silos) that can be added in small increments or modules as needed may provide a relatively inexpensive, flexible alternative to water basins for interim storage.

SOURCE: Office of Technology Assessment.

The Act also ensures that long-term storage under active human control will be available, if needed. It requires DOE to submit to Congress a proposal for construction of one or more MRS facilities, including an analysis of the need for such facilities, their feasibility, and how they might be integrated into the waste management system. The role of retrievable *storage* in the waste management system is an important issue that remains to be resolved. However, the Act requires *disposal* in geologic repositories to proceed, regardless of what is done about MRS facilities.

It now appears that MRS facilities will not be necessary for safe management of high-level radioactive waste unless major unexpected difficulties with geologic disposal are encountered. NRC has determined that spent fuel can be safely stored at reactor sites for at least 30 years after the reactor is decommissioned. Analysis by OTA indicates that if the two repositories required by the Act are operating at full scale by 2008 and 2012, respectively, spent fuel could be removed from all reactor sites within 10 to 15 years after the reactors are expected to cease operation. MRS or other backup isolation facilities, if operating by the same dates, would provide the same margin of safety.

Relations With States and Indian Tribes

State and Tribal Role in Siting Decisions

NWPA requires DOE to engage in an extensive process of consultation with States and affected Indian tribes throughout the repository site selection and development process. The Act gives the State or tribe the right to veto the President's selection of a repository site, a veto that can only be overridden by joint action of both Houses of Congress. Similar provisions apply to other waste management facilities addressed by the Act. Because of the distrust that had arisen between the Federal waste program and the States, legislated guarantees of clearly specified rights in the siting process were needed to provide a stable basis for intergovernmental relations during the implementation of the Act.

Impact Compensation

Waste management activities will produce many of the negative impacts associated with other industrial activities, such as the "boomtown" effects of large construction projects in small communities, as well as less familiar ones arising from the radioactive nature of the waste. NWPA requires DOE to make payments from the Nuclear Waste Fund (see below) to States, affected Indian tribes, and in some cases local governments, to compensate for the negative impacts of development and operation of waste management facilities. These arrangements should help assure those States and localities that they will not bear a disproportionate share of the burden of radioactive waste management. However, there will probably be positive impacts as well. For example, the first repository—which is likely to be the first such facility in the world—may become an international research center on high-level radioactive waste disposal. Such a center would produce long-term benefits for the community that might offset the more immediate but short-term adverse impacts of repository construction.

Institutional Measures

Waste Disposal Fee

DOE estimates that the total program outlays for high-level radioactive waste management through the year 2028 could range from as little as $16 billion to as much as $114 billion, depending on inflation and technical variations. A middle range, assuming 3 percent inflation, is from $35 billion to $64 billion.

To provide the assured source of funds to maintain steady progress over a period of decades, NWPA establishes a Nuclear Waste Fund financed by a mandatory fee on nuclear-generated electricity. The fee is initially set at 1 mill (0.1 cent) per kilowatt-hour. The rate must be reviewed annually by the Secretary of Energy and adjusted as needed to ensure that the full costs of the Federal waste disposal program are recovered. (Studies by DOE and the Congressional Budget Office conclude that some fee increase will likely be needed to cover inflation and possible increases in program costs.) This arrangement allows funding levels to be determined by the legislated goals, rather than having the achievable goals limited by the availability of funds, as occurred in the past. In return for this fee, DOE is required to sign con-

tracts with utilities to dispose of waste after the first geologic repository is available. DOE will take title to the waste at the owner's site and transport it to the repository for disposal.

Single-Purpose Waste Management Office

NWPA establishes within DOE a single-purpose Office of Civilian Radioactive Waste Management, headed by a Presidential appointee and separate from the other nuclear activities of DOE. This step will help to insulate the program from the competition for manpower and policy-level attention that has adversely affected the program in the past. It could also help to provide the degree of central, integrated planning and management that is needed to meet long-term commitments on schedule. At the same time, the Act requires DOE to submit a study of alternative means of financing and managing the waste management program, including such options as establishing a private corporation.

Radioactive Waste Management Mission Plan

NWPA also requires DOE to submit to Congress a detailed Mission Plan for fulfilling the requirements of the Act. Such a Plan would provide a key tool for program management and for congressional oversight of DOE's waste management activities. **In OTA's view, development of a highly credible Mission Plan is the crucial next step in building confidence that the job of waste management will get done in a safe and timely manner.** The issues to be resolved in the Mission Plan are discussed below.

REMAINING ISSUES

Issues in the Mission Plan

According to NWPA, the Mission Plan is intended to provide "an informational basis sufficient to permit informed decisions to be made." To do this, the Mission Plan needs to identify the key strategic decisions and options involved in developing the proposed waste management system, and to provide information and analysis to support a choice among the options. The major strategic issues in the Mission Plan concern:

1. *the long-term waste management plan*—a plan for transferring spent fuel or high-level waste from the owners' storage facilities to Federal disposal facilities—involving a repository loading schedule, a plan for spent fuel storage after 1998, and a plan for providing long-term alternatives if major difficulties are encountered with geologic repositories; and
2. *the implementation program* for carrying out that plan, involving a repository siting program and a technology development program.

The choices among options for the repository schedule and the technology development and repository siting strategies represent key decisions in the Mission Plan. **Because the implications are so significant, the Mission Plan should include a comparative evaluation of alternative repository development and siting strategies, including those developed in the OTA Mission Plan.** This would enable Congress to evaluate the strategy selected by DOE in the light of a more detailed comparison of alternatives than OTA

was able to perform. It would also allow DOE to explain and justify its choices, thereby increasing the credibility of the Mission Plan and the entire waste management program. The *Draft Mission Plan* published in 1984 does not explain the choices DOE has made, nor does it evaluate alternatives to those choices.

In OTA's view, development by DOE of an achievable, responsive Mission Plan is the crucial next step for stabilizing the waste management program and for establishing the necessary level of confidence and support. If the Mission Plan leaves some affected parties strongly dissatisfied with the way major questions are resolved, there will be a continued risk of future policy shifts like those that have characterized the program in the past, and the credibility of long-term Federal commitments will suffer. An acceptable Mission Plan might provide a key tool for program management and for congressional oversight of DOE's waste management activities, but dissatisfaction would probably result in strong opposition to giving the program greater managerial and financial independence than it already has. **In fact, it may not be possible to gain broad support for the creation of an independent waste management organization until a widely accepted Mission Plan is developed.**

While analyzing NWPA, OTA identified the basic elements of a Mission Plan that meets these requirements. This "OTA Mission Plan" is conservative in goals but aggressive in action, and OTA believes that it will be widely regarded as feasible and achievable. Its major elements are summarized below, in order to support OTA's conclusion that there is at least one workable approach to managing nuclear waste using the authority provided by NWPA. In general, it represents an expansion, rather than a redirection, of the approach DOE followed in the past and presented in the *Draft Mission Plan*. DOE can proceed with its ongoing repository development activities without precluding consideration of the strategic options suggested by OTA.

The following discussion highlights the key strategic choices to be made in implementing NWPA and identifies areas in which additional analysis by DOE would provide valuable information for congressional deliberations.

Repository Loading Schedule

Geologic repositories are the only facilities authorized and required by NWPA for DOE to use for fulfilling its legal responsibility for waste disposal. For this reason, the repository program is the heart of the OTA Mission Plan. The crucial decision concerning the repository loading schedule is the balance between the degree of *certainty* that the schedule can be met, and the promised *speed* of the schedule. Developing a geologic repository involves many first-of-a-kind technical and institutional steps. The faster the promised schedule, the less margin there is for delays or problems at any of these steps, and the less confident one can be that the schedule can be met.

DOE's *Draft Mission Plan* uses a repository schedule that can only be met if no significant delays are encountered. Initial loading at the first repository is scheduled to begin in 1998, the date NWPA requires, with full-scale operation expected by about 2001. DOE does not specify when loading might begin if there are serious problems or major delays. Questions about the credibility of the Federal waste management program in the past have stemmed

in part from similarly optimistic schedules that have not been met. The credibility of DOE's Mission Plan would be enhanced if contractual commitments do not assume that everything will go right the first time.

OTA concludes that small-scale operation of the first repository probably can begin by the NWPA deadline of January 31, 1998, if a suitable site can be found from among those already under consideration at the time the Act was passed. The OTA Mission Plan therefore uses this date as a management target for *initial* operation, to maintain pressure for steady progress towards a licensed repository site. It also includes additional measures, discussed below, to increase confidence in that target.

Although NWPA establishes a deadline for *initial* disposal in a repository, however, it does not specify how quickly the *full-scale* transfer of waste from utilities to the repository is to occur. The Mission Plan needs to do so. This *repository loading schedule* then becomes the basis for contractual commitments, in order to give utilities a basis for planning interim storage. The OTA Mission Plan uses a conservative repository loading schedule based on two repositories in full-scale operation by 2008 and 2012, dates that can be met despite major delays or problems. **If the contingencies allowed for in this schedule do not arise, full-scale operation could begin years earlier—perhaps as early as provided in DOE's proposed schedule.**

Repository Siting Strategy

The major issue in siting and developing the geologic repositories is the balance between: 1) the desired degree of certainty that a repository will be available without major delays; and 2) the initial costs of the program, both financial and political. **It is impossible to both maximize the certainty of the repository schedule and minimize the initial costs at the same time.** The implementation program in the OTA Mission Plan emphasizes certainty and places great weight on the importance of minimizing the risk of major programmatic delays. **This approach increases the level of confidence in the repository schedule and perhaps reduces overall costs, but it may also increase the initial costs.** The repository siting strategy is crucial to this approach.

DOE's *Draft Mission Plan* provides for considering only the number of sites required by NWPA at key stages of the siting process. Specifically, three sites would be characterized for each repository, and one site would be submitted to NRC for construction authorization. This is unchanged from the program that was in place before NWPA made a major Federal commitment in law to operating a repository on a firm date. **OTA's analysis indicates that expanding that program to include one additional site at those key stages is both necessary and sufficient to substantially increase the level of confidence that the new commitment made by NWPA will be met.**

The siting process is the principal source of uncertainty in the repository program. Because there is no previous experience with most of the technical and institutional problems involved, there is no consensus on how much time will be required to complete each stage or the likelihood that a given site will be rejected at any stage. The best way to increase confidence that major delays will be avoided, in the face of these uncertainties, is to carry more than the required number of sites through each stage. This ensures that backups are

available without delay if needed, so that extended delays or failures at any one site will not hold up the entire process.

The OTA Mission Plan includes a siting program that exceeds the requirements of NWPA in two principal areas: characterizing four sites for each repository, instead of three; and recommending two sites for each construction authorization, rather than one. Using an expanded siting strategy significantly increases the likelihood of meeting the 1998 deadline for *initial* operation. This strategy is the principal assumption underlying OTA's conclusion that the first repository could be in *full-scale* operation by 2008 despite difficulties with some sites.

NWPA requires that characterization be *completed* at three sites before one can be recommended. Beginning the characterization stage with four sites allows a site to be recommended as soon as the fastest three sites are finished; if only three sites are characterized, the schedule depends on progress at the slowest site. Similarly, submitting two sites to NRC for licensing, rather than one, means that construction could proceed as soon as either site receives authorization.

It is also possible that NWPA may be interpreted as requiring three sites that, after characterization, appear *suitable* for licensing, before one can be *recommended* for licensing. Characterizing four sites provides insurance against the delay that could result from a lawsuit to resolve this question. This approach also increases the credibility of the State veto provisions of NWPA by increasing the likelihood that Congress will have a readily available alternative, if and when it has to decide whether to overrule a State's objection to the final site. (The Act requires DOE to recommend a second site within one year in the event that Congress upholds a State objection. This can only be done if a second *suitable* site is available from among the first set of sites that are characterized.)

The OTA Mission Plan calls for only one additional site at each stage for reasons of cost effectiveness. Again, the Act requires characterization of three sites before one can be recommended; even if there is only a 20 percent risk of delay or rejection at an individual site during characterization, there would be nearly a 50 percent risk of delay in having all three sites ready for the next stage. Adding a fourth site during characterization reduces that overall risk to 18 percent, a significant improvement, but adding a fifth site provides a smaller improvement, to 6 percent. Similarly, if there is a 20 percent risk that a single recommended site will be rejected for construction authorization, recommending two sites reduces the risk to 4 percent, while recommending a third reduces the risk only to 1 percent.

OTA's analysis suggests that the additional costs of an expanded implementation program would produce offsetting benefits that are not readily quantifiable. First, it increases the credibility of the process by allaying concerns that key decisions might be compromised by lack of suitable alternatives. Second, it substantially reduces the risk that the credibility of the Federal program might be damaged by major delays in the repository program. Because of its troubled history, any major programmatic failure—real or perceived—could have grave consequences for both the waste management program and the continued use of nuclear power. **The greater initial costs of the OTA Mission Plan may thus be regarded as insurance for a program that can-**

not afford any major failures or delays. NWPA provides authority for such an approach, as well as a source of funding that can be adjusted to cover its costs. DOE's *Draft Mission Plan*, on the other hand, proposes measures to speed up the repository development process, at significant cost, but these measures do not provide the insurance against major delays offered by consideration of additional sites.

Technology Development Strategy

The OTA Mission Plan calls for development of the first repository to be accomplished in two stages: 1) a *demonstration phase*, to show that a licensable disposal technology exists; and 2) an *operational phase*, to dispose of radioactive waste on a large scale.

The demonstration phase would use a *conservative system design* that emphasizes certainty in meeting regulatory requirements. A small amount of waste (e.g., several hundred tonnes) would be placed in conservatively designed packages during the packaging and handling RD&D program required by NWPA. Permission would be requested from NRC to emplace this material in the repository as soon as possible following construction authorization—*before* the repository's packaging facilities are built instead of after, as indicated in DOE's *Draft Mission Plan*. (If DOE builds an unlicensed test and evaluation facility at the repository site, as authorized by NWPA, the demonstration phase could be simply a licensed extension of the activities conducted in that facility.) Using a conservative system design, involving low repository temperatures and a waste package whose lifetime exceeds NRC's requirements, would reduce the number of technical issues to be resolved before initial licensed emplacement is allowed. This approach would allow early demonstration of both the technology and the institutional steps required for licensed disposal. It should thereby maximize the likelihood of meeting NWPA's 1998 target for initial repository operation.

The operational phase would use an *optimized, integrated system design*, aimed at reducing the overall risks, costs, and impacts of waste management operations, from discharge of spent fuel from a reactor to final disposal in a repository. For example, recent analysis suggests that significant operational benefits, including substantially reduced costs, might result from using a universal container—a package into which spent fuel would be placed at the reactor and in which it would remain for all subsequent waste management steps, unless it were removed for reprocessing. **Because this container and other relatively new technologies will require additional RD&D, the schedule for the operational phase would be determined by the time required to develop and license an optimized system design.**

This two-stage approach may increase initial costs compared to DOE's *Draft Mission Plan*, because it requires development of two disposal system designs and may defer full-scale operation for a few years. At the same time, it may reduce total costs in the long run because: 1) it removes the construction of the repository's packaging facility from the critical path for initial disposal; and 2) it thereby avoids the risk that attempting to meet the 1998 deadline using those facilities, as proposed by DOE, might preclude the use of a significantly improved system design at the first repository. In addition, it increases confidence in the schedule for full-scale operation, because the con-

servative system design could still be used if problems were encountered with the optimized design.

Issues in the MRS Proposal

The second document to be submitted to the 99th Congress is the MRS proposal, containing both designs for such facilities and an analysis of the need for them and their feasibility. As noted earlier, it now appears that MRS facilities will not be necessary for safe waste management unless major unexpected difficulties with geologic disposal are encountered. The OTA Mission Plan provides for a delayed decision to construct MRS facilities (or alternative disposal facilities) as a long-term backup to repositories, in the event that major unanticipated difficulties are encountered with geologic disposal.

The major storage issue to be considered in the Mission Plan and the MRS proposal is whether to authorize earlier construction of an MRS facility. To facilitate congressional consideration of MRS options, both the Mission Plan and the MRS proposal should evaluate at least three alternatives:

1. **Early siting, licensing, and construction of an MRS facility.** This could be done for several reasons: to provide a cushion against delays in the repository program; to play an operational role in an integrated waste management system; or to allow more time to be taken in finding repository sites. This option, which is implicit in DOE's *Draft Mission Plan,* would require congressional authorization in the very near future. It involves a major additional commitment of manpower and resources over the next decade, which might raise concerns that this effort would adversely affect the repository siting process.
2. **Federal at-reactor storage beginning in 1998.** Under this option, the Nuclear Waste Fund would pay the costs of additional storage beyond the contractual delivery date. This avoids the costs of siting and licensing a large new facility, and it would spread the costs of delays in the repository program among all utilities paying the waste disposal fee. This option might be accomplished through rulemaking, by modifying contracts with utilities; if so, no congressional action would be required. This approach is compatible with a later decision to construct a centralized storage facility, if needed, but it would also allow planning for at-reactor storage as an integral part of the waste management system. If it were taken by DOE soon, it would separate the equity issue of *who* should be responsible for post-1998 interim storage from the technical question of *where* that storage can best be provided.
3. **Deferral of the decision on a centralized MRS facility until at least 1990, when DOE expects to recommend the first geologic repository site to Congress.** This allows enough time to: 1) evaluate the demonstrations of at-reactor dry storage technologies required by NWPA; 2) complete the analysis of an optimized integrated waste management system design that has recently been initiated by DOE; and 3) determine from the results of site characterization whether the repository program can expect significant delays. It also avoids the risk that an early effort to site a large-scale storage facility would delay the repository program. If a decision were made in 1990 to construct an MRS facility, it could begin operation by 2001, DOE's current target date for operation of

the full-scale loading facilities for the first repository. Even if the decision were made as late as 1998, it would still allow alternative facilities to be available quickly enough to remove spent fuel from reactor sites within 15 years after decommissioning. This option would require no congressional action at this time.

Institutional Issues

Finally, DOE will submit to the 99th Congress a report on alternative institutional mechanisms for financing and managing the commercial high-level radioactive waste program. The central component of NWPA is its commitment to developing a complex technological system, faced with technical and institutional uncertainties, on a firm schedule extending over a period of decades. **The confidence in and credibility of this commitment could be enhanced by establishing an independent waste management agency with more funding and management flexibility than is usual with a typical Federal program.** Creating such an agency may be the best way to ensure that implementation of NWPA would not be adversely affected by other fiscal and political priorities of the Federal Government. In addition, separating this agency from Federal activities that promote energy production could enhance the credibility of the program for those who see a conflict of interest between such activities and the safe planning and development of a waste management system.

The degree of financial independence of the waste management organization will be of particular importance. NWPA insulates the revenues produced by the waste management fee by establishing a separate Nuclear Waste Fund in the Treasury, limited to carrying out the purposes of the Act. Although the budget for the program is to be submitted and expenditure levels authorized on a triennial basis, the use of the Fund is subject to annual appropriations. Since annual budget control is not entirely consistent with a commitment to steady progress on a long-term schedule, any future deliberations on establishing an independent waste management agency will have to consider ways of providing such an agency with greater budgetary independence. Without such independence, there will be a risk that considerations of the annual Federal budget (e.g., pressures to limit the temporary borrowing from the Treasury that may be needed to balance the flow of revenues and expenditures in the Waste Fund) could lead to deferral or elimination of planned expenditures. This could in turn jeopardize steady progress on a program whose schedule has been fixed by contracts with utilities.

Achieving an acceptable balance between independence and accountability will be one of the central challenges in designing such a waste management authority. The more independent the institution and its funding are, the surer the guarantee that nuclear waste management activities will be carried out on schedule. But such an institution raises a crucial and difficult question: how to ensure the congressional oversight and public accountability that a democratic society demands. There may be considerable reluctance to establish a single-purpose agency with even greater independence than the current institutional structure, for fear that it might be less responsive to the concerns of Congress, the administration, and the public.

The Mission Plan could serve as the principal mechanism for balancing the need for adequate congressional oversight with the need for increased flexibility of operation. Using the Mission Plan for this purpose could be easier and more effective if there were a process by which Congress could approve it. Since this is not now required by NWPA, consideration of mechanisms for such approval might be included in any congressional deliberations on establishment of an independent waste management agency.

If there were a mechanism for congressional approval of a Mission Plan, the function of the waste management agency would be that of carrying out a specific program, with specific goals that Congress has formally approved, and not that of developing broad waste management policy. This might give Congress sufficient ongoing control to warrant relaxation of normal annual budgetary controls, thus increasing confidence that the waste management program will have adequate funds available when needed regardless of other Federal budget priorities. Once congressional approval is obtained, the agency could be authorized to make expenditures from the Nuclear Waste Fund, as provided for in a multiyear budget contained in the Mission Plan, without annual authorizations or appropriations. To ensure continued congressional control, revision and reapproval of the Mission Plan could be required at regular intervals (e.g., every 4 to 6 years).

The added independence that could be gained under this approach might give the waste management agency the incentive to develop and carry out a highly defensible and widely supported Mission Plan. A regular process of review and reapproval could increase public understanding of and support for waste management activities. It would also allow Congress to reconfirm its commitment, made in NWPA, that there would be steady progress toward the permanent disposal of high-level radioactive waste.

NOTE: Copies of the full report "Managing the Nation's Commercial High-Level Radioactive Waste" can be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, GPO stock No. 052-003-00980-3.

General Information

Information on the operation of OTA, the nature and status of ongoing assessments, or a list of available publications may be obtained by writing or calling:

Congressional and Public Affairs Office
Office of Technology Assessment
U.S. Congress
Washington, DC 20510
(202) 226-2115

Publications Available

OTA Annual Report.—Details OTA's activities and summarizes reports published during the preceding year.

List of Publications.--Catalogs by subject area all of OTA's published reports with instructions on how to order them.

Press Releases.—Announces publication of reports, staff appointments, and other newsworthy activities.

OTA Brochure.—"What OTA Is, What OTA Does, How OTA Works."

Assessment Activities.—Contains brief descriptions of assessments under way and recently published reports.

Contacts Within OTA

(OTA offices are located at 600 Pennsylvania Ave., S.E., Washington, DC)

Office of the Director	224-3695
Congressional and Public Affairs Office	224-9241
Energy, Materials, and International Security Division	226-2253
Health and Life Sciences Division	226-2260
Science, Information, and Natural Resources Division	226-2253
Administration Office	224-8712
Personnel Office	224-8713
Publications	224-8996

U.S. GOVERNMENT PRINTING OFFICE : 1985 O - 44-015

CONGRESS OF THE UNITED STATES
OFFICE OF TECHNOLOGY ASSESSMENT
WASHINGTON, D.C. 20510

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
OFFICE OF TECHNOLOGY ASSESSMENT

OTA-O-277

MARCH 1985